of advanced sensor driven control systems may be used to accomplish this, such as adaptive feedback, artificial intelligence, using local, remote, contacting or non-contacting temperature sensors to assure fidelity to the temperature requirements.

There are numerous control strategies for ensuring that the energy delivered to the bond zone remains above a critical level. For example, using the above grid-type methods, a look-up table of welding parameters to deliver appropriate energy levels could be applied to any given welding location. Alternatively, modern adaptive feedback control techniques could be employed to ensure that process inputs are controlled continuously and variably using mathematical process models to generate appropriate levels of energy input to the weld zone, with the power signal as feedback. Other artificial intelligence based control techniques, including but not limited to expert systems, fuzzy logic or neural networks could also be employed in the controller to the same ends. It is the intent of this to be exemplary only; one skilled in the art will appreciate the wide range of real-time control technologies available to apply to the problem, and it is the intent of the inventors to cover all of these methods for ensuring that the energy delivered to the bond zone via the ultrasonic power train remains above the critical level required to produce true metallurgical bonding.

Those skilled in the art will appreciate that the control of a continuous, constantly varying manufacturing process, with numerous inputs, outputs, sensing and process control techniques available can be implemented as an engineering activity in a number of ways. The schematic shown in Figure 6 is a broad exemplary depiction of possible methods for performing closed loop control of the UOC process employing any one or more of the techniques described herein. Open loop control methods, while note illustrated here, are also possible implementations and are not meant to excluded by the more sophisticated example given.

I claim:

1. In an additive manufacturing process of the type wherein material increments are consolidated at a bond zone to produce a part, a method of maintaining uniformity in fabrication, comprising the following steps alone or in combination:

maintaining consistent energy delivery to the bond zone;

maintaining consistent stiffness and mechanical resistance to vibration in the bond zone; and

maintaining uniform thermal conditions in the bond zone.

2. The method of claim 1, wherein the step of maintaining consistent energy delivery to the bond zone includes the steps of:

determining the local geometry of the part being fabricated; and

using the local geometry to apply appropriate weld parameters.

3. The method of claim 2, including the step of specifying the local geometry in terms of current bond zone width, height of feature, or location with respect to initiation or termination of the bond zone.

4. The method of claim 3, wherein the appropriate weld parameters calculated in real time in accordance with the local geometry.

5. The method of claim 3, further including the use of a look-up table containing previously identified weld parameters.

6. The method of claim 3, further including the use of an adaptive control method to derive the level of energy required for a uniform weld at the bond zone.

7. The method of claim 6, wherein the adaptive control method is based upon a Kalman filter or pole placement.

8. The method of claim 6, wherein the adaptive control method is based upon artificial intelligence.

9. The method of claim 6, wherein the artificial intelligence technique is based on a rule-based system, fuzzy logic, neural network, or genetic algorithm.

10. The method of claim 1, wherein the step of maintaining consistent stiffness and mechanical resistance to vibration in the bond zone includes controlling applied force, the amplitude of the delivered energy, or welding speed.

11. The method of claim 1, wherein the step of maintaining consistent stiffness and mechanical resistance to vibration in the bond zone includes the use of initiation and termination process parameters during bonding.

12. The method of claim 11, wherein the initiation and termination process parameters are a function of the energy applied to the feature being built, the instantaneous aspect ratio of the part as it is built, the width of the feature, or the ratio of a feature dimension to feed dimension.

13. The method of claim 11, wherein the initiation and termination process parameters include force, speed, and/or ultrasonic wave amplitude.

14. The method of claim 11, wherein the initiation and termination process parameters are used to compensate for variations in the solid mechanics of the component as its geometry changes.

15. The method of claim 11, wherein the initiation and termination process parameters are used to initiate the moving flowing plastic flow front at the interface

between previously deposited material and the volume of material currently being applied.

16. The method of claim 1, further including the steps of:

using a grid or other geometric map to identify the aspect ratio and/or volume of discrete features on the object;

finding height-to-width ratio and/or total volume based upon the aspect ratio and/or volume of the discrete features; and

assigning appropriate processing parameters as a function of height-to-width ratio and/or total volume.

17. The method of claim 16, wherein the processing parameters include speed, pressure and/or amplitude.

18. The method of claim 16, wherein the step of finding height-to-width ratio and/or total volume uses a look-up table.

19. The method of claim 16, further including the step of determining whether or not to incorporate a support or stiffening feature through the use of the grid or other geometric map.

20. The method of claim 1, further including the step of varying feedstock geometry to increase the degree of relative motion in the X-Z or Y-Z plane.

21. The method of claim 20, further including the step of using geometries which include an angle in the relevant directions.

22. The method of claim 1, wherein the step of maintaining consistent stiffness and mechanical resistance to vibration in the bond zone includes the use of a

support feature which is conducive to easy removal during trimming and finishing of the part.

23. The method of claim 22, wherein the support feature is a stepped buttress.

24. The method of claim 22, wherein the support feature is continuous, intermittent, applied around corners, applied only at corners, on the periphery of an entire part, at the periphery of a specific feature on a larger part, or along an edge.

25. The method of claim 1, wherein the step of maintaining uniform thermal conditions in the bond zone includes controlling the temperature of the build/part being produced, the substrate, the feedstock or the fabrication environment.

26. The method of claim 22, wherein the bond zone is heated to a temperature near the temperature of the feedstock.

27. The method of claim 22, wherein the bond zone is heated to a temperature between 0.2 and 0.8 of the melting temperature of the feedstock material.

28. The method of claim 22, further including the step of controlling the local thermal history in the bond zone using process parameter control, supplementary thermal control, or a combination thereof.

29. The method of claim 22, wherein the temperature of the entire build is controlled to within a desired temperature range.

30. The method of claim 29, including the use of a heat source secured to a build platform.

31. The method of claim 22, wherein the heat source is an electric base heater, IR heater, induction heater, radiative heater, strip heater, resistance heater, heat blanket, lasers, torch, or electronic heater.

32. The method of claim 22, wherein the heat source includes the use of air, hot water, hot oil, or steam.

33. The method of claim 22, wherein the heat is supplied through channels built into the growing object, etc.

34. The method of claim 22, wherein the heat source is controlled by a closed-loop process-parameter control system.

35. The method of claim 22, wherein the closed-loop process-parameter control system uses contacting or non-contacting temperature sensors.

36. The method of claim 22, including the use of local as opposed to general heating of the part.

37. The method of claim 36, wherein the local heating is provided by a laser, or other high intensity light source.

38. The method of claim 37, wherein the local heating source travel along with an ultrasonic sonotrode.

39. The method of claim 22, including the step of generating a consistent thermal profile by heating of the feedstock, a sonotrode or both.

40. The method of claim 22, including the use of an open- or closed-loop technique for ensuring that the temperature remains within a set range.

41. The method of claim 40, wherein the technique includes a sensor driven control system based upon adaptive feedback or artificial intelligence.

42. The method of claim 40, wherein the technique includes the use of an expert system, fuzzy logic or neural network.

43. The method of claim 1, wherein the step of maintaining consistent stiffness and mechanical resistance to vibration in the bond zone includes the use of secondary materials.